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Review article

Selecting the surgical approach for revision total hip arthroplasty

L. Kerboull

Institut Marcel Kerboull, 2a, avenue de Ségur, 75007 Paris, France

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ABSTRACT

Selecting the approach for revision total hip arthroplasty is a crucial step in pre-operative planning. Whether the surgical objectives can be reached via a conventional approach or require a specific approach must be determined. The best approach depends on multiple factors including the reason for revision, patient's characteristics, implants requiring removal, previous approach, soft tissue and bone lesions, and surgeon's level of experience. These factors are discussed herein, as well as the potential and limitations of conventional approaches and the indications for specific approaches.

1. Introduction

The plethora of publications on surgical approaches for primary total hip arthroplasty (THA) is in striking contrast to the scarcity of articles on approaches for revision THA. A 1998 study by Materson et al. [1] of the factors influencing surgical approach selection for revision THA is still relevant today. In 2004, Glassman [2] described his strategy for choosing among four approaches, ranging from a simple posterior approach to extended trochanteric osteotomy, depending on the complexity of the problem to be treated. A 2006 instructional course lecture on revision THA strategies written by Puget [3] emphasises the need for discernment in selecting the best approach. Paumier and Doré [4] wrote a comprehensive and detailed review of trans-osseous approaches in 2010. Here, revision THA approaches are discussed based on an analysis of the literature and personal experience.

Revision THA involves building a new artificial hip whose architecture and fixation will restore function for many years. Revision THA is usually a lengthy and technically demanding procedure.

Optimal pre-operative planning is crucial. The surgical objectives must be defined, any difficulties anticipated, specific implants obtained, and a need for grafting recognised. The approach must be selected with discernment as it influences the conduct of all the steps of the procedure.

To be optimal, the approach must meet a number of specific criteria. To ensure that no further damage is inflicted, the approach must adequately expose the components to be removed (implants and cement within or outside the bone tissue). In addition, the approach must allow the reconstruction not only of all the bony defects identified pre-operatively, but also of those discovered intra-operatively. Finally, preservation of bone and soft tissue must be as complete as possible.

The present article has three parts. The first part discusses the pre-operative factors that influence surgical approach selection. The second reviews the main approaches used for primary THA and details the advantages and drawbacks of each for revision THA. Finally, the third part focusses on the approaches developed specifically for revision THA and describes the situations in which these approaches must be used. A technical description of all the available approaches would be beyond the scope of this article, and detailed information on the approaches mentioned in this article can be found in excellent papers written by Nazarian and Müller [5] in 1998 and by Paumier and Doré [4] in 2010.

2. Pre-operative factors that influence selection of the surgical approach

Based on an evaluation of these factors, the surgeon can determine whether the revision procedure can be performed via a conventional approach, which may be the approach used for the primary procedure or another more appropriate approach; or whether the use of a specific approach should be considered from the outset.

2.1. Reason for revision surgery

Depending on the reason for revision surgery, removal of one or two well-fixed implants may be required.

Aseptic loosening, the leading reason for revision THA in France [6], is usually due to polyethylene wear and chiefly affects the cup. Isolated exchange of the cup is an attractive option, as it limits the aggressiveness of the procedure for the patient and the technical difficulties encountered by the surgeon. Nevertheless, care must be taken to ensure that this option is reasonable:

E-mail address: luc.kerboull@gmail.com

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the pre-operative evaluation must check the absence of femoral metaphyseal osteolysis; determine whether the femoral component is a monoblock or modular implant, verify its compatibility with the new cup; and assess the need for correcting a pre-existing architectural abnormality related to the femoral component such as inadequate anteversion, leg length inequality, or inadequate femoral offset restoration. These factors limit the indications for isolated cup revision, as shown by De Thomasson et al. [7]. When the appropriateness of isolated cup revision is confirmed, use of the previous approach may be a good option to avoid further soft tissue damage, provided the exposure will be sufficient to perform all the steps of the acetabular revision and the surgeon is experienced in the use of the approach.

Acute infection is generally treated via the initial approach, as the revision is usually a simple procedure aimed at excision of the infected tissues. Implant exchange is rarely needed, although the acetabular insert and femoral head may need to be changed to allow optimal cleansing. Chronic infection raises different issues: concomitant implant loosening and spread of the infection to the soft tissues is a common situation that requires complete excision of all intra-osseous and extra-osseous lesions. For this reason, the initial approach is suitable only if it can be easily extended proximally and distally to allow thorough cleansing.

Revision procedures for instability and for leg length inequality share common features. An essential step is identification of the cause of the problem, which determines whether the revision can be confined to a single component or whether both components must be changed. In the event of instability or leg length inequality requiring shortening, gluteal muscle tension must be increased, which requires a trans-trochanteric approach with lowering of the trochanter [8].

Psoas syndrome is related to anterior overhang of the acetabular implant and is usually treated by isolated acetabular revision. This procedure can be performed via the initial approach in most cases.

Changing a non-cemented femoral implant responsible for thigh pain is difficult if osteo-integration of the implant has been achieved. Use of the initial approach is not always feasible and the need for a femorotomy to extract the implant must be anticipated.

2.2. Type of implant and fixation method

The type of acetabular implant has little influence on selection of the surgical approach. A cemented femoral implant is usually easy to extract, particularly if it is loose, regardless of the approach used. However, removal of the cement, particularly distally, may raise variable challenges depending on the approach. This point must be given consideration before the procedure in order to determine whether a conventional or specific approach is needed to allow cement removal with no risk of damaging the femur. Although rarely used in France, cemented rough femoral implants with surface grooves or notches or an outer layer of methylmethacrylate are difficult to remove when well fixed, and their tight connection to the cement may require a femorotomy.

The removal of a well-fixed non-cemented femoral component requires a detailed pre-operative evaluation of the implant characteristics including shape, flange, type and extent of surface coating, and contact with cortical bone. The ability to anticipate in part any difficulties raised by implant removal provides a rationale for either attempting the revision via a conventional approach or determining from the outset that a femorotomy is required.

2.3. Influence of the soft tissue and bone lesions

Deep soft tissue lesions fall into two categories: granulomas, which may be due to infection or to an aseptic reaction to particles; and muscle lesions. The former should be removed and the latter repaired whenever possible.

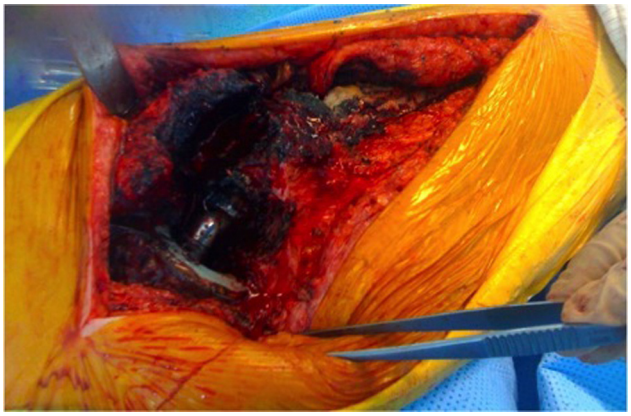

Fig. 1. Metallosis requiring an extensive approach to allow excision of the lesions.

Excision of a granuloma requires appropriate pre-operative imaging studies to determine the extent of the lesion, which governs the selection of the approach. Granulomas may spread in all directions, and a limited approach such as the anterior approach may fail to readily allow complete excision. In particular, metallosis (Fig. 1) can cause huge granulomas, whose excision requires extensive dissection. In this situation, a conventional approach allowing only limited extension is not adequate.

Muscle lesions are challenging to repair, as they are often related to tendon detachment or section and worsened by involution of the muscle belly. Repair options are limited. An imperfectly healed digastric flap after a trans-gluteal approach can be re-attached to the trochanter. Lowering the trochanter can improve the efficiency of a damaged gluteus medius muscle. To be optimally treated, these lesions must first be recognised and, therefore, the approach must allow their visualisation. For example, it seems unwise to perform revision surgery via an anterior approach after primary trans-gluteal THA, as this strategy would fail to allow the diagnosis of defective digastric flap healing.

Concomitant bone lesions are key to selection of the approach, which must allow their reconstruction.

The pre-operative evaluation must determine the location and size of any bone lesions in order to guide the choice of the approach. At the acetabulum, greater upwards and posterior extension of the lesions increases the need for approaches providing broad exposure of the upper iliac wing and posterior column. At the femur, distal osteolysis, cortical defects, and malalignment always require an approach that provides direct exposure of the femoral shaft.

2.4. Influence of previous incisions

The most common problem is a scar that seems to have shifted anteriorly or posteriorly. The previous incision may be used, the subcutaneous tissue detached from the aponeurosis, and the incision of the aponeurosis re-centred to obtain the optimal position for approaching the deep tissues. Excision of the scar and subcutaneous tissue, which are often sclerotic and tight, is useful to produce healthy margins, whose approximation allows suturing under good conditions. Finally, any dehiscence of the aponeurosis must be repaired.

2.5. Influence of patient characteristics

The specific characteristics of the patients may seem of limited importance and have little influence on selection of the approach.

However, obesity or muscular hypertrophy may result in limited exposure. Depending on the type of revision procedure, these characteristics may require approaches that allow simple extension of soft tissue dissection and muscle mass displacement. Furthermore, the operative time may need to be kept short if the patient is in poor general health. For instance, when difficulties with femoral implant extraction are anticipated, the use of a specific approach from the outset may seem preferable over a sequential strategy consisting in a conventional approach with attempted extraction via the cervical opening followed by a femorotomy if this method fails.

2.6. Influence of surgeon experience and training

Orthopaedic surgeons with high THA volumes choose one or more surgical approaches depending on personal training-related factors, as well as on environmental factors reflecting technological advances and, in some cases, current trends.

None of the approaches used for primary THA allows the management of every possible problem. Consequently, surgeons who perform technically challenging revisions must acquire training in specific approaches then use these approaches regularly to ensure their reliable execution.

Importantly, marked proficiency on the part of the surgeon undoubtedly broadens the capabilities of each primary approach. For instance, in expert hands the anterior approach can be used for challenging revision procedures, as reported by Nogler et al. [9].

3. Indications and limitations of conventional approaches

Many approaches and variants have been described. For purposes of simplification, they can be divided into four categories based on their location relative to the abductor muscles [5], a crucial criterion that largely dictates their effectiveness for revision surgery.

Anterior approaches are anterior to the gluteus medius, trans-gluteal approaches involve detaching the anterior bundle of the gluteus medius and the gluteus minimus from the greater trochanter, trans-trochanteric approaches include an osteotomy of the greater trochanter, and posterior approaches run posterior to the gluteus medius and through the lateral rotators of the hip. Table 1 shows the quality of acetabular and femoral exposure obtained with each of these categories.

3.1. Anterior approaches

3.1.1. Anterior approaches lie anterior to the tensor fasciae latae

Examples include the Smith-Petersen approach [5] and, in France, the Hueter approach modified by Robert Judet [5] (known as the Hueter-gaine approach). Anterior approaches have generated renewed interest in recent years as a mean of sparing the muscles, since they pass through an interval between muscles and nerves. Some groups have reasoned that their recognised advantages for primary THA may warrant their use for revision surgery. Nevertheless, their limitations are easily recognised. For acetabular revision, although exposure of the anterior column and lower portion of the acetabulum is fairly easy to achieve, the treatment of large postero-superior and posterior bone defects is far more challenging and requires considerable experience with anterior approaches. This step is even more difficult to perform when the femoral implant is left in place.

To obtain good exposure, the hip must be flexed to relax and displace the anterior muscles. Superiorly and posteriorly, the capsule must be extensively detached and the anterior portions of the gluteus minimus and medius muscles must be separated from the bone. Exposure of the femur is also difficult to achieve, particularly when cement or a non-cemented femoral implant must be removed. Exteriorisation of the femoral shaft always requires complete release of the posterior and antero-inferior capsule and, in most cases, detachment of the lateral rotators of the hip if still present. In some cases, partial or complete detachment of the proximal insertion of the tensor fasciae latae may be required, as recommended by Nogler et al. [9]. Thus, the theoretical muscle-sparing advantage is rapidly lost and, despite detachment of the above-listed muscles, the ease of exposure remains limited.

Moreover, the manipulations required to expose the femur carry a risk of fracture of the greater trochanter or even of the femoral shaft, and this risk is increased when the femur is weakened by osteolysis. In addition, there is no obvious advantage to using an anterior approach when the primary THA was performed via a posterior approach, since exposure is more limited and the lateral rotators of the hips already cut, so that there are no muscles to preserve posteriorly. Finally, it must be emphasised that the distal femur cannot be directly exposed via anterior approaches. Either a lateral counter-incision must be performed or the incision must be prolonged in an arc to the lateral aspect of the thigh in order to provide access to the femur [9].

3.1.2. Anterior approaches between the tensor fasciae latae and gluteus medius

Anterior approaches between the tensor fasciae latae and gluteus medius (Watson-Jones approach and variants) are even more limited. Proximal extension in the event of an acetabular defect is limited by the neuro-vascular bundle of the tensor fasciae latae. Access to the posterior column is always restricted, and this limitation is particularly marked when the femoral component is left in place. Finally, access to the canal is hampered by the anterior bundle of the gluteus medius, which must be detached preventively to ensure that it is not torn during the manoeuvres needed to prepare the canal. Nazarian and Müller [5] advocated severing the lateral rotators of the hip via the intra-articular approach to allow mobilisation of the femur, a step that results in additional damage to the tendons and muscles.

3.1.3. Conclusion

In conclusion, it seems reasonable to consider that anterior approaches are best confined to isolated acetabular revision and, in our opinion, to patients whose primary THA was performed via the same approach.

Table 1
Quality of exposure of the acetabulum and femur with conventional approaches.

Approach	Acetabular exposure			Femoral exposure		
	Anterior	Superior	Posterior	Metaphysis	Canal	Lateral cortex
Hueter/Smith-Petersen	+++	++	+	++	+	+
Watson-Jones	++	+	+	++	++	+++
Trans-gluteal	++	+	++	+++	++	+++
Trans-trochanteric	+++	+++	+++	+++	+++	+++
Posterior	++	+++	+++	+++	++	+++

Fig. 2. Narrow interval between the trochanter and iliac wing hindering dislocation of the femoral head.

3.2. Trans-gluteal approaches

Hardinge described the first trans-gluteal approach, in which only the anterior portion of the gluteus medius is detached from the greater trochanter [10]. Subsequently, many variants were developed. Exposure is similar with all these approaches.

Access to the upper part of the acetabulum is limited by the nerve supply to the gluteus medius, which courses about 4 cm above the greater trochanter. Access to the posterior column is fairly challenging and a complementary posterior articular approach behind the gluteus medius has been recommended [1]. If the interval between the trochanter and iliac wing is narrow (Fig. 2), dislocation of the femoral component may be difficult and may carry a risk of femoral fracture. After dislocation of the femur, access to the femoral canal is simpler and more readily achieved than via an anterior approach, with good exposure of the femoral shaft. Distal extension of the approach towards the shaft is always feasible simply by lifting the vastus lateralis in addition to the splitting of this muscle performed for the digastric approach.

The other limitation of trans-gluteal approaches pertains to the quality of the repair of the detached digastric flap. Healing to the greater trochanter is often incomplete. In addition, after limb lengthening or an increase in femoral offset, contact between the flap and greater trochanter is not readily obtained, the suture is under tension, and satisfactory healing is even less likely to occur.

In conclusion, trans-gluteal approaches are of limited usefulness for complex revision procedures. For simple revisions, they should be considered only if used previously. The adverse effect of repeated passages through the gluteus medius on the function of this muscle should be borne in mind. Finally, when a trans-gluteal approach was used for the primary THA procedure, caution mandates a careful check of digastric flap healing, and every effort should be made to improve digastric flap repair if necessary.

3.3. Trans-trochanteric approaches

Long popular under the influence of Charnley and Ferrera [11], trans-trochanteric approaches were gradually discarded for primary surgery then for revision surgery, because of potential trochanteric problems, of which the most dreaded is non-union

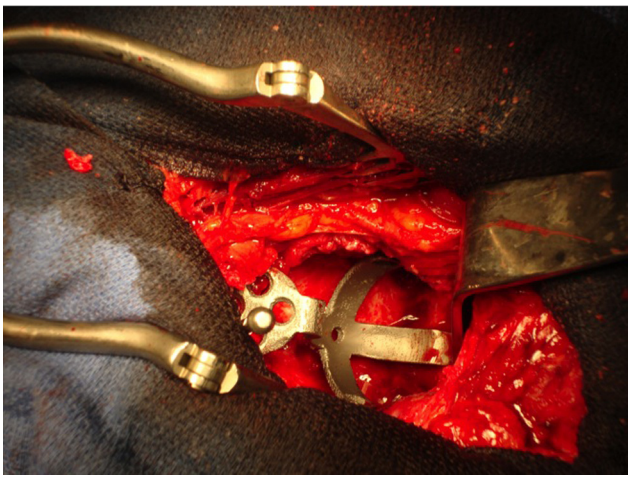

Fig. 3. Circumferential acetabular exposure via a trans-trochanteric approach.

of the trochanteric fragment. The results reported by Courpied and Migaud [12] in 2000 at a symposium on revision THA underline the devastating effect of technical imperfections on the likelihood of trochanteric union. A number of variants of the classic procedure have been developed, particularly by Courpied et al. [13] and by Dall [14], in the hope of promoting trochanteric union by maintaining muscle and tendon continuity between the gluteus medius and the vastus lateralis.

The anterior hemi-trochanterotomy described by Dall [14] is actually a trans-gluteal approach in which an anterior trochanteric fragment is cut to ensure continuity between the gluteus medius and the vastus lateralis. Thus, this approach shares the characteristics and limitations of the other trans-gluteal approaches.

The digastric trochanterotomy developed by Courpied et al. [13] preserves the continuity between the trochanter and vastus lateralis. The lateral rotators of the hip remain attached to the femur and can hinder its exteriorisation. Vinciguerra et al. [15] reported their experience with digastric trochanterotomy for revision THA and concluded that the healing rate was improved and the quality of exposure unchanged compared to conventional trochanterotomy.

In our experience, the flat osteotomy technique described by Kerboull [8] remains preferable. The greater trochanter is completely detached in the distal-to-proximal direction. All the advantages of the technique are preserved, with extensive exposure and complete preservation of the lateral rotators and gluteus minimus, if still present. At the end of the procedure, the trochanteric fragment is easily reinserted in the position that ensures optimal tension and efficiency of the gluteus medius.

The non-union rate in revision surgery is low, 1% in our experience [16] and 3% according to Schutzer and Harris [17]. These rates demonstrate the influence of expertise with the repair technique on the incidence of non-union.

Several key points deserve attention. The trochanteric fragment must be sufficiently thick to preserve all the attachments of the gluteus muscles and lateral rotators and to prevent breakage of the fragment when it is handled and the wires are tightened. The use of an oscillating saw facilitates the osteotomy and, importantly, decreases the aggressiveness of the cut when the bone is weakened by a granuloma. Finally, two slender scissors passed on either side of the femoral implant can be used to lift the trochanter without damaging it. The trochanter is then gradually lifted above the roof of the acetabulum by separating the muscle fibres from the capsule, which is often thick and sclerotic.

This approach exposures the full circumference of the acetabulum (Fig. 3) and allows the treatment of complex bone defects (Fig. 4). On the femoral side, proximal exposure is readily achieved

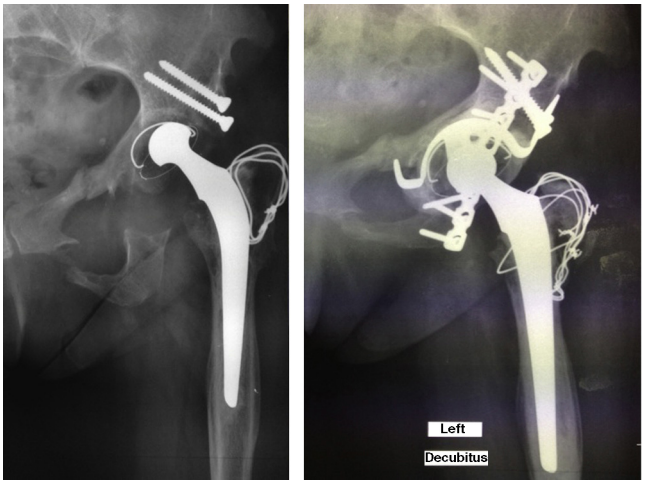

Fig. 4. Reconstruction of the acetabulum combined with internal fixation of the inferior pubic ramus.

after excision of the fibrous tissue that hinders exteriorisation of the femur. This step allows work along the axis of the femur, with safe removal of the implant and, if present, of the cement. However, extraction from the canal of cement extending very far distally may be difficult, particularly if the femoral curvature is marked. For non-cemented implants, the simple access to the metaphysis allows an attempt at extraction through the cervical opening, since slender blades or wires can be passed between all four aspects of the implant and the bone to try to disrupt the link with the cortex. Failure of these manoeuvres requires femorotomy, which is simple to perform via this lateral approach.

The main issue raised by this approach is trochanteric repair using a method that minimises the risk of non-union. Many repair techniques have been described, most notably by Jando et al. [18]. In our experience [19], the most reliable technique is fixation by steel wires, if needed combined with a trochanteric claw plate. Outcomes of this method have been reported by Hamadouche et al. [20]. The claw plate and wires confer greater rigidity and, above all, decrease the risk of fatigue fracture of the wires when healing is slow to occur. In addition, grafting of the trochanter and its insertion site on the femur is necessary to promote healing (Fig. 5).

In conclusion, we believe the trans-trochanteric approach is the best choice for bipolar revision THA and complex acetabular revisions. If the femoral component is left in place, it is displaced anteriorly or posteriorly and does not hinder access to the acetabulum. The trochanter is then repaired by running the steel wires through two tunnels drilled in the lateral cortex anterior and posterior to the greater trochanter.

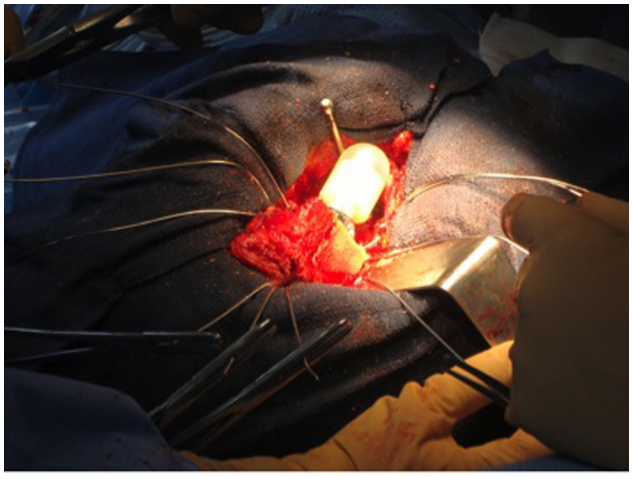

Fig. 5. Allograft reconstruction of the footprint of the greater trochanter on the femur.

3.4. Posterior approaches

The posterior approaches are the most often used for both primary and revision THA. This popularity is ascribable to their simplicity of execution; the nearly circumferential exposure of the acetabulum; the ability to displace the femoral component (if spared) anteriorly, particularly if the gluteus maximus tendon is cut; and, finally, the feasibility of extending the approach towards the femur.

Nevertheless, posterior approaches also have several limitations. At the acetabulum, bone defects located very proximally require anterior displacement of the gluteus medius, over a considerable distance, which may damage the nerve supply to the muscle. This problem prompted Solomon et al. [21] to suggest rasping the muscle belly off the iliac bone down to the greater sciatic notch, with the goal of decreasing traction on the neuro-vascular bundle. At the femur, access to the canal via the cervical opening is hampered by the greater trochanter, increasing the risk of cortex perforations during cement removal. For the same reason, the passage of slender blades between the posterior aspect of a non-cemented prosthesis and the bone is difficult and carries a risk of greater trochanter fracture if the bone is weakened by osteolysis.

The main drawback of posterior approaches is the permanent damage to the lateral rotators of the hip, which increases the risk of post-operative instability. Posterior repair of the capsule and tendons during primary THA decreases the risk of instability but is not consistently feasible during revision surgery. In contrast, preventing hip instability is probably the best reason for choosing a dual-mobility acetabular implant for surgery via a posterior approach [6].

In conclusion, the posterior approaches allow all the procedures required for revision and can therefore be likened to the trans-trochanteric approaches. Nevertheless, they do not allow muscle re-tensioning and are more limited in terms of work on the femoral canal via the cervical opening.

4. Specific approaches for revision surgery

4.1. Acetabular revision

Most major defects, even those with discontinuity, can be approached and reconstructed via standard approaches, most notably the posterior and trans-trochanteric approaches.

Nevertheless, in a few exceedingly rare situations, direct access to the anterior part of the iliac wing may prove necessary to perform internal fixation of the anterior column. In this case, the ilio-inguinal approach described by Letournel [22] for internal fixation of acetabular fractures is extremely useful.

Implant or cement migration into the pelvic cavity can result in injury to organs or blood vessels within the pelvis. Removal of the migrated material through the acetabular defect often requires traction, which may tear vessels or organs, as these often adhere to the granuloma and fibrous tissue in contact with the material. Imaging studies, most notably arteriography, provides a detailed evaluation of the relationships of the blood vessels with the implants. If the results show close contact or alterations in vessel trajectory, a direct sub-peritoneal approach to the pelvic cavity allows dissection and displacement of the vessels and organs, thereby ensuring safe removal of the implants.

4.2. Femoral revision

Direct access to the canal via a cortical osteotomy of variable complexity and size may be required in specific circumstances, such as a very distal cement plug, a fractured implant, a well-fixed and fully coated non-cemented implant, or marked curvature of the femur. Pre-operative planning of these extensive approaches is crucial to ensure execution and repair under optimal conditions. The key technical point is anticipation of the size and location of the cortical flap based on an assessment of the length of the material to be removed (implant or cement plug) and of its direction on the lateral radiograph. The creation of multiple adjoining flaps should be avoided to limit the risk of non-union.

The second key point consists in determining the minimal length of the new implant that ensures optimal position of the distal anchoring point relative to the distal edge of the flap. This safety distance depends on the type of revision implant selected (cemented, non-cemented and locked, or non-cemented and press-fit), as well as on the configuration of the femur and quality of the bone.

The third key point is faultless technique in performing the femorotomy. A slender saw should be used to limit the loss of bone due to the thickness of the blade, and the saw should be oriented in a way that confers a trapezoidal shape to the edge of the cut, as this improves stability during flap repair. An appropriately sized window should be created from the outset, if needed by marking the edges with drill holes to stop the oscillating saw, and the distal part should be bevelled to promote healing at this site by increasing the surface area of the contact zone.

The fourth key point is femorotomy repair using rigid and tight cerclage to produce close contact between the fragments. Close contact is not always easy to achieve when the new implant is bulky, as is often the case given the design of non-cemented revision implants. With cemented implants, the flap should be repaired first and the degree of implant subsidence must then be checked, since tightening of the flap may decrease the diameter of the canal, requiring further reaming. Care should be taken to avoid the interposition of cement, which would impair healing of the flap. Bone grafting to strengthen the assembly is useful and extremely effective.

The trans-osseous femoral approach has a number of variants, which are described below, from the simplest to the most complex.

4.2.1. Isolated postero-lateral corticotomy

Because the femur is elastic, isolated postero-lateral corticotomy sometimes allows the removal through the cervical opening of a non-cemented implant that is either not in close contact with the cortices or partially coated. The cut is started at the cervical opening in contact with the implant and stopped at the distal end of the implant. A slim chisel is introduced into the corticotomy and held in place. Axial extraction manoeuvres through the cervical opening are often successful in mobilising the implant.

If this method fails, the corticotomy is converted to a flap to provide greater access to the implant. The flap is then closed by two or three transverse cerclage wires.

4.2.2. Cortical flap (or cortical window)

When broader exposure is required, a cortical flap is created. The location and size of the flap are planned pre-operatively (Fig. 6). Detachment of the vastus lateralis should be as economical as possible, and the muscle attachments to the flap should be preserved whenever possible. The flap is usually rectangular [23], although an oval variant described by Materson et al. [1] has the theoretical advantage of decreasing the risk of fracture at the angles of the flap. One or more cerclage wires depending on the size of the flap are placed to ensure bone healing.

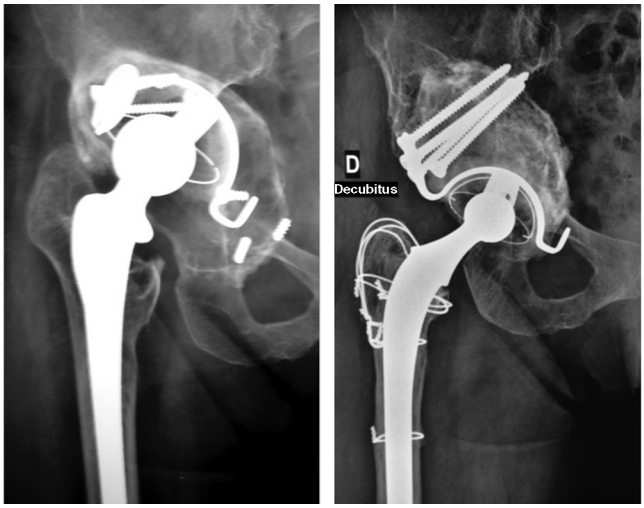

Fig. 6. Trochanterotomy combined with a long cortical flap to extract a long non-cemented stem.

The 'sarcophagus' technique described by Paumier and Doré [4] involves creating several separate small flaps to limit the weakening of the cortex seen with large flaps. Paumier and Doré specified that the stem must bridge the distalmost flap.

4.2.3. Extended trochanterotomy

If a flap is required from the outset, it can be made continuous with the greater trochanter. This technique, known as extended trochanterotomy, provides the advantages of digastric trochanterotomy and direct access to the canal. As described by Younger et al. [24], it is being used increasingly in the US and UK and, in some cases, is even performed routinely to treat infections, as recommended by Levine et al. [25].

In most cases, this technique combines an extensive posterior approach and a postero-anterior osteotomy of the trochanter in continuity with a femoral cortical flap. If the implant is too bulky to allow the saw to exit through the anterior cortex, the anterior corticotomy is performed using an osteotome, through the fibres of the vastus lateralis to limit detachment of this muscle and to protect the blood supply to the flap. Canadian authors such as MacDonald et al. [26] prefer the combined use of an anterior trans-gluteal approach to limit damage to the posterior capsule. We believe there is little to support this method, except if the primary THA was performed through the trans-gluteal approach.

In Europe, Wagner [27], as well as Picault and Vives [28], standardised these trans-femoral approaches for use with non-cemented revision implants. They emphasised the importance of preserving the muscle attachments to ensure an adequate blood supply to the flap. Picault and Vives [28], in particular, described initial detachment of the linea aspera to protect the posterior blood supply and to produce a bony strut that serves as a pedicled graft.

Multiple longitudinal osteotomies can be added to extract a non-cemented femoral implant when osteo-integration is particularly marked.

Finally, either induced fracture or a medial transverse osteotomy may be required to allow alignment of a misshapen femoral shaft or to improve the reduction of the flap and shaft in contact with the revision implant.

The main advantage of extended trochanterotomy, in addition to facilitated extraction of the femoral implant and/or cement, is greater ease of internal fixation and improved healing of the greater trochanter left continuous with the cortical fragment and attachment of the vastus lateralis (Fig. 7). In the ideal situation, repair is easily achieved, as it requires simple cerclage of the lateral cortex. In

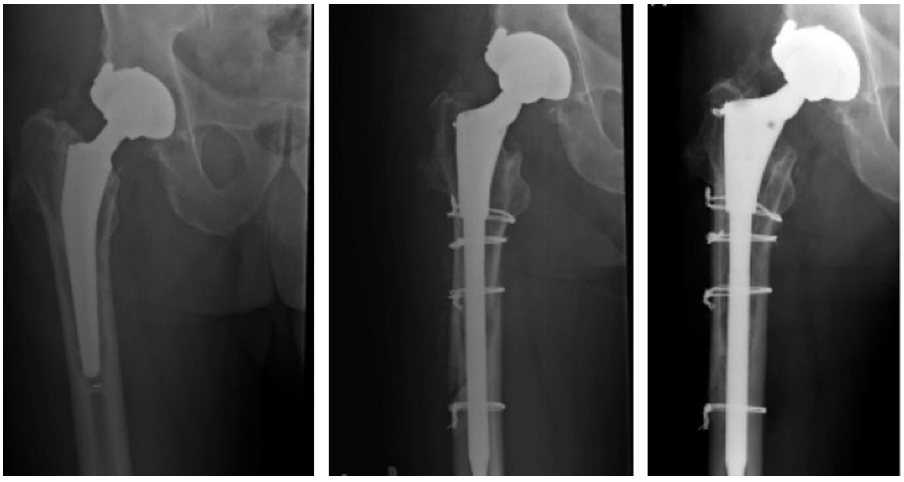

Fig. 7. Example of extended trochanterotomy. The usefulness of extended trochanterotomy in this indication is open to debate.

practice, the conditions may be less favourable. If the lateral femoral cortex is weakened or the lateral part of the implant is bulky, the continuity between the trochanter and flap may be disrupted during the manipulations. Separation of the trochanter from the flap increases the complexity of the repair procedure. Simple fixation by suture metallic wires oriented transversally to the implant is not sufficient in this situation, as it does not adequately counter the proximal traction by the gluteus medius. A classic internal fixation technique with sagittal suture metallic wire and, in many cases, a claw plate must be performed.

Non-cemented revision implants are often used with this approach. Their frequently considerable bulk may preclude complete reduction of the flap, particularly with long straight implants that cannot follow the curvature of the proximal femur. A fracture may occur at the junction between the trochanter and cortical flap when the cerclage wire is tightened. Healing is slower and may even fail to occur in this situation.

Furthermore, the greater trochanter is difficult to lower when an extended trochanterotomy is performed. The distal part of the flap must be resected and slipped downward, which often decreases the quality of the reduction.

This approach is technically very demanding, has a long learning curve, and may be extremely difficult to repair. It should therefore be reserved for patients in whom direct access to the canal is required and a classic trochanterotomy with a separate flap is deemed undesirable. The choice between these two options also depends on whether a cemented or non-cemented revision implant is used.

5. Conclusion

Our training and preferences lead us to restrict our practice to two or three approaches. The use for revision surgery of the conventional approach performed by the surgeon on a daily basis holds considerable appeal. A surgeon who is highly skilled in the use of an approach can overcome many of its limitations in order to perform fairly difficult revision procedures. Nevertheless, awareness of the unsurmountable limitations of each approach is crucial, and surgeons must acquire experience with other approaches.

A reasonable conclusion is that the posterior approach and the classic or digastric trans-trochanteric approaches are best able to solve all possible problems. Unfortunately, the classic trans-trochanteric approach is falling into disuse and is therefore less often taught. This trend is regrettable given the advantages of the classic trans-trochanteric approach in this indication.

The current trend consists in routinely performing a more or less extensive trans-femoral approach. We believe the routine use of this approaches is criticisable. Although trans-femoral approaches clearly facilitate implant removal, they weaken the femur and require the use of a long stem, which is far from being consistently necessary. In many cases, the same result can be obtained without disrupting cortical continuity by performing all the extraction and reconstruction steps via the canal, which allows the safe use of a standard stem.

Disclosure of interest

The author declares that he has no conflicts of interest concerning this article.

References

[1] Materson EL, Masri BA, Duncan CP. Surgical approaches in revision hip replacement. J Am Acad Orthop Surg 1998;6:84–92.
[2] Glassman AH. Exposure for revision total hip replacement. Clin Orthop Relat Res 2004;420:39–47.
[3] Puget J. Stratégie dans les reprises de prothèse totale de hanche. In: Conférence d'enseignement. Paris: Elsevier; 2006. p. 43–68.
[4] Paumier FL, Doré JL. Voie d'abord transosseuse dans les RPTH. In: Puget J, Chaminade B, editors. Reprise des prothèses de hanche. Paris: Elsevier Masson SAS; 2010. p. 264–78.
[5] Nazarian S, Müller ME. Voies d'abord de la hanche. In: EMC - Techniques chirurgicales-Orthopédie-Traumatologie. Paris: Elsevier; 1998. p. 44–600 [36 p.].
[6] Delaunay C, Hamadouche M, Girard J, Duhamel A, SOFCOT group. What are the causes for failures of primary hip arthroplasties in France. Clin Orthop Relat Res 2013;471:3863–9.
[7] De Thomasson E, Conso C, Mazel C. A well-fixed femoral stem facing a failed acetabular component: to exchange or not? A 5 to 15 years follow-up study. Orthop Traumatol Surg Res 2012;98:24–9.
[8] Kerboull M. Arthroplastie totale de hanche par voie transtrochantérienne. In: EMC - Techniques chirurgicales-Orthopédie-Traumatologie. 2e ed Paris: Elsevier; 1994. p. 44–665 [12 p.].
[9] Nogler M, Mayr E, Krismer M. The direct anterior approach to the hip revision. Oper Orthop Traumatol 2012;24:153–64.
[10] Hardinge K. The direct lateral approach to the hip. J Bone Joint Surg Br 1982;64:17–9.
[11] Charnley J, Ferrera A. Transplantation of the greater trochanter in arthroplasty of the hip. J Bone Joint Surg Br 1964;46B:191.
[12] Courpied JP, Migaud H. Reprise fémorale dans les arthroplasties itératives aseptiques de la hanche. Symposium. Rev Chir Orthop 2000;86(Suppl. I):33–90.
[13] Courpied JP, Desportes G, Postel M. A new trochanteric osteotomy method for a postero-lateral approach of the hip (330 operations with posterior transosseous and paramuscular curved approach). Rev Chir Orthop 1991;77:506–12.
[14] Dall D. Exposure of the hip by anterior osteotomy of the greater trochanter: a modified antero-lateral approach. J Bone Joint Surg Br 1986;68:332–86.
[15] Vinciguerra X, Pascarel P, Mangione JL, Honton JL. La trochanterotomie digastrique dans les reprises de prothèse totale de hanche. À propos de 53 cas. Rev Chir Orthop 1993;79:200–4.

[16] Kerboull L, Hamadouche M, Kerboull M. Impaction bone grafting in association with the Charnley-Kerboull femoral component: operative technique and two- to 16-year follow-up results. J Bone Joint Surg Br 2009;91(3):304–9.
[17] Schutzer SF, Harris WH. Trochanteric osteotomy for revision total hip arthroplasty. 97% union rate using a comprehensive approach. Clin Orthop Relat Res 1988;227:172–83.
[18] Jando VT, Greidanus NV, Masri BA, Garbuz DS, Duncan CP. Trochanteric osteotomies in revision total hip arthroplasty: contemporary techniques and results. Instr Course Lect 2005;54:143–55.
[19] Kerboull M, Kerboull L. Traitement chirurgical des descellements fémoraux aseptiques. Reconstruction osseuse par allogreffe et reprise par prothèse cimentée. In: EMC - Techniques chirurgicales-Orthopédie-Traumatologie. Paris: Elsevier; 2000. p. 44–676 [10 p.].
[20] Hamadouche M, Zniber B, Dumaine V, Kerboull M, Courpied JP. Reattachment of the ununited greater trochanter following total hip arthroplasty. J Bone Joint Surg Am 2004;86-A(Suppl. 1):112–8.
[21] Solomon LB, Hofstaetter JG, Bolt MJ, Howie DW. An extended posterior approach to the hip and pelvis for complex acetabular reconstruction that preserves the gluteal muscles and their neurovascular supply. J Bone Joint Surg Br 2014;96:48–53.
[22] Letournel E. The treatment of acetabular fractures through the ilioinguinal approach. Clin Orthop 1993;292:62–76.
[23] Moreland JR, Marder R, Anspach Jr WE. The window technique for the removal of broken femoral stems in total hip replacement. Clin Orthop 1986;212:245–9.
[24] Younger TI, Bradford MS, Magnus RE, Paprosky WG. Exended proximal femoral osteotomy: a new technique for femoral revision arthroplasty. J Arthroplasty 1995;10:329–38.
[25] Levine BR, Della Valle CJ, Hamming M, Sporer SM, Berger RA, Paprosky WG. Use of the extended trochanteric osteotomy in treating prosthetic hip infection. J Arthroplasty 2009;24(1):49–55.
[26] MacDonald SJ, Cole C, Guerin J, Rorabeck CH, Bourne RB, McCalden RW. Extended trochanteric osteotomy via the direct lateral approach in revision hip arthroplasty. Clin Orthop Relat Res 2003;417:210–6.
[27] Wagner H. Prothèse de révision de l'articulation coxo-fémorale. Orthopade. Berlin: Springer Verlag; 1989.
[28] Picault C, Vives P. Voie d'abord trans-fémorale et tige à verrouillage distal dans les échecs fémoraux des prothèses totales de hanche. Montpellier: Sauramps Médical; 1999.